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AN OVERVIEW OF SLAC EXPERIMENT E158: PRECISION MEASUREMENT OF $sin^2(\theta_w)$ AWAY FROM THE Z POLE

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ABSTRACT

SLAC Experiment E158 is a precision measurement of parity violation in Møller scattering in which ∼50 GeV longitudinally polarized electrons scatter off unpolarized electrons in a liquid hydrogen target. The resulting left-right parity-violating asymmetry is proportional to $(\frac{1}{4} - sin^2\theta_w)$, where θ_w is the electroweak mixing angle. Experiment E158 will provide the most precise measurement to date of θ_w off the mass of Z^0 boson at a Q^2 of $0.003(GeV/c)^2$. This measurement will provide an important test for the Standard Model with TeV scale sensitivity to new physics. The predicted Standard Model asymmetry is $1.9 \cdot 10^{-8}$. The E158 goal is to measure this asymmetry to an accuracy of better than 10^{-8}, which corresponds to $\delta(sin^2\theta_w) \sim 0.0007$. In our poster we presented an overview of the E158 experimental setup as well as our performance during the 2002 run.

1 Motivation

SLAC experiment E158 is an e^-e^- fix target experiment. A beam of longitudinally polarized (polarization $>$ 80%) e^- of 45GeV(or 48.3GeV) collides with a 1.5 meter long target of liquid H_2 (unpolarized). The produced interactions are mainly ($e^-e^- \longrightarrow e^-e^-$) Moller scattering, ($e^-N \longrightarrow e^-N$) elastic scattering and

$(e^- N \longrightarrow e^- X)$ inelastic scattering. The experiment goal is to measure the asymmetry in the cross section of the Moller scattering

$$A_{LR} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} \tag{1}$$

with a precision of 10^8. In equation 1 $\sigma_R(\sigma_L)$ is the cross section for incident right(left) helicity electrons. In the Standard Model A_{LR} is due to the interference between weak and electromagnetic Feynman diagrams. At the tree, level for E158 kinematics (at a Q^2 of $0.003(GeV/c)^2$), A_{LR} is about 3.2 10^-7. Radiative corrections reduce it to about 1.8 10^-7. From A_{LR} one can extract $sin^2\theta_w$. E158 goal is $\delta(sin^2\theta_w) \sim 0.0007$, this gives unique sensitivity to new physics at the TeV level (compositeness, GUTs, extra dimensions, lepton flavor violation).

2 Experimental Challenges

The degree of precision desired requires: 1)large statistics (the goal is for 600 million pairs of pulses on target, each pulse of about 5 $10^1 1e$, from which 1/10000 is detected). 2)An electron beam polarized source photocathode capable of produce high polarization with high electron intensity. 3)High beam stability, intensity jitter $< 1\%$, spotsize jitter $< 10\%$, position jitter $< 10\%$. 4) small beam helicity correlated asymmetries and differences in beam intensity ($A_I < 210^{-7}$), beam position and angle ($\Delta_x < 10nm$), beam energy ($A_E < 210^{-8}$). 5)precise electron beam monitoring devices, toroid resolution < 30 parts per million (ppm), beam position monitor resolution $< 1\mu m$ per pulse, energy resolution <50 ppm per pulse. 6)stable liquid H_2, density fluctuations $< 10^{-4}$ 7)A high flux-integrating calorimeter detector with resolution <100 ppm per pulse, with nonlinearity $< 1\%$ and able to perform well after high radiation damage. 8)Compatible with PEPII operation (BaBar collaboration experiment). 9)Theoretical predictions of eP elastic and inelastic asymmetries which are important backgrounds to our measurement.

3 Results from 2002 Run

E158 had its first physics run in 2002, 6 weeks May-June. Approximately 250 million pulses were logged. We are performing a blind analysis (Moller asymmetry value randomly offset) which we expect to complete by the end of September 2002. We obtain a $\sigma_{A_{LR}} = .024$ ppm (stat). In table 1 we give electron beam delivery and monitoring performance and in table 2 the electron beam asymmetries and their contributions to the Moller asymmetry.

Table 1: Electron Beam Delivery and Monitoring.

	Final Goal	Run I (2002)
Beam Charge	6×10^{11}	6×10^{11}
Intensity Jitter	2%	.5%
Position Jitter	$< 10\%$	5%
Spotsize Jitter	$< 10\%$	5%
Energy Spread	.3% rms	.1% rms
Energy Jitter	.2% rms	.03% rms
Polarization	75%	85%
Target BPM x,y	$1\mu m$	$2\mu m$
Target BPM x',y'	$.4\mu rad$	$.1\mu rad$
Energy BPM	30 ppm	40 ppm
Target Toroid	30 ppm	60 ppm

Table 2: Electron Beam Asymmetries.

	beam A_{LR}	Contribution to Moller A_{LR}(stat)	Contribution to Moller A_{LR}(sys)
Intensity	340 ppb	5.7 ppb	3.4 ppb
Energy	5 ppb	2.6 ppb	<1 ppb
Position	15 nm	1.0 ppb	∼1 ppb
Angle	.25 nrad	1.0 ppb	∼1 ppb
Spotsize	.7 nm	2.5 ppb	∼1 ppb
all		∼7.0 ppb	∼4 ppb

4 Future

E158 will run 6 weeks October-November 2002 and probably 6 weeks at the end of 2003, hopefully completing the experiment.